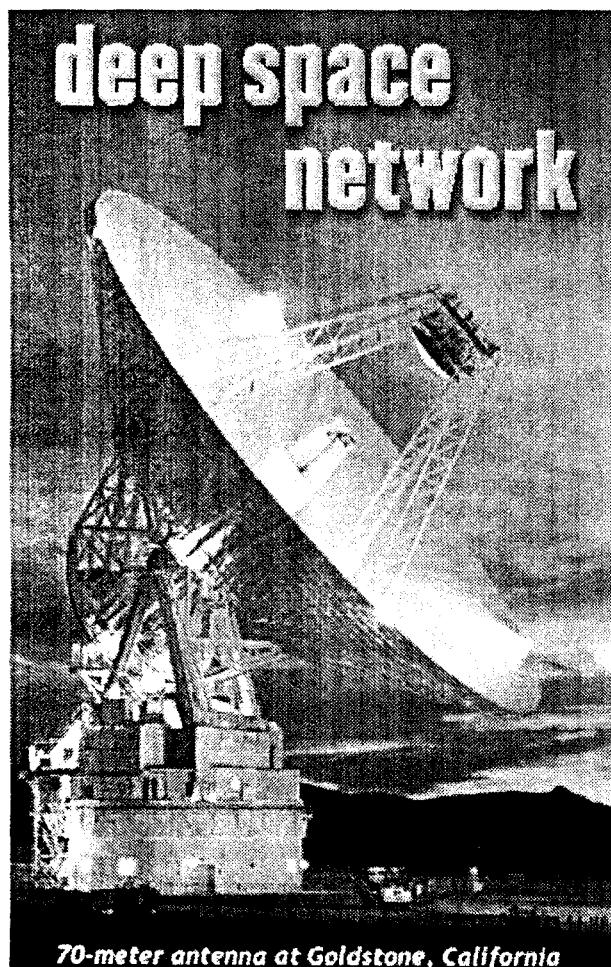


Goldstone Lunar Neutrino Search



JPL:

Peter Gorham, Kurt Liewer, Chuck Naudet

UCLA:

David Saltzberg, Dawn Williams (2001)

Support:

JPL DSN Science Services (G. Resch & M. Klein) (JPL staff)

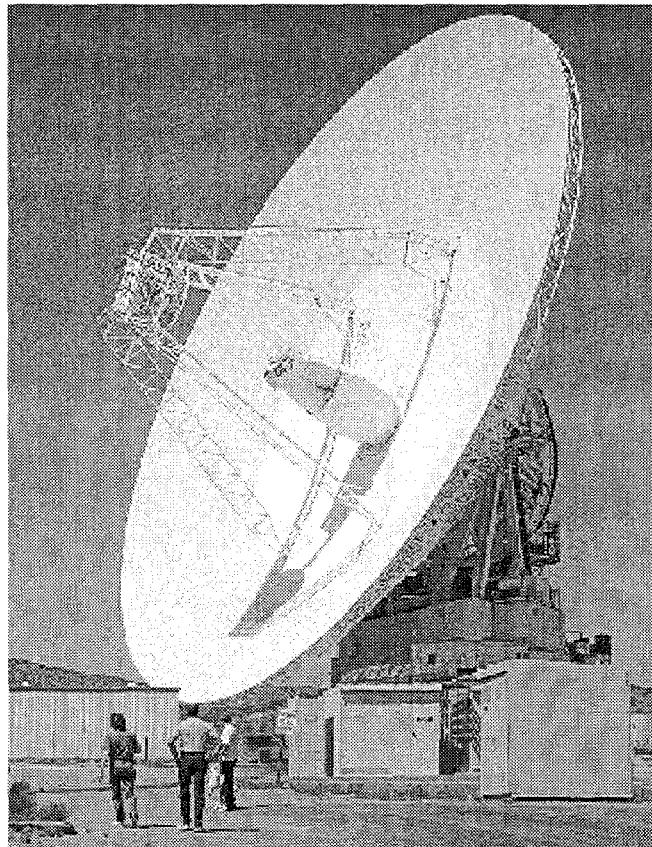
Caltech President's Fund (PG & DS)

DOE & NSF Career Awards (DS)

Background & motivation

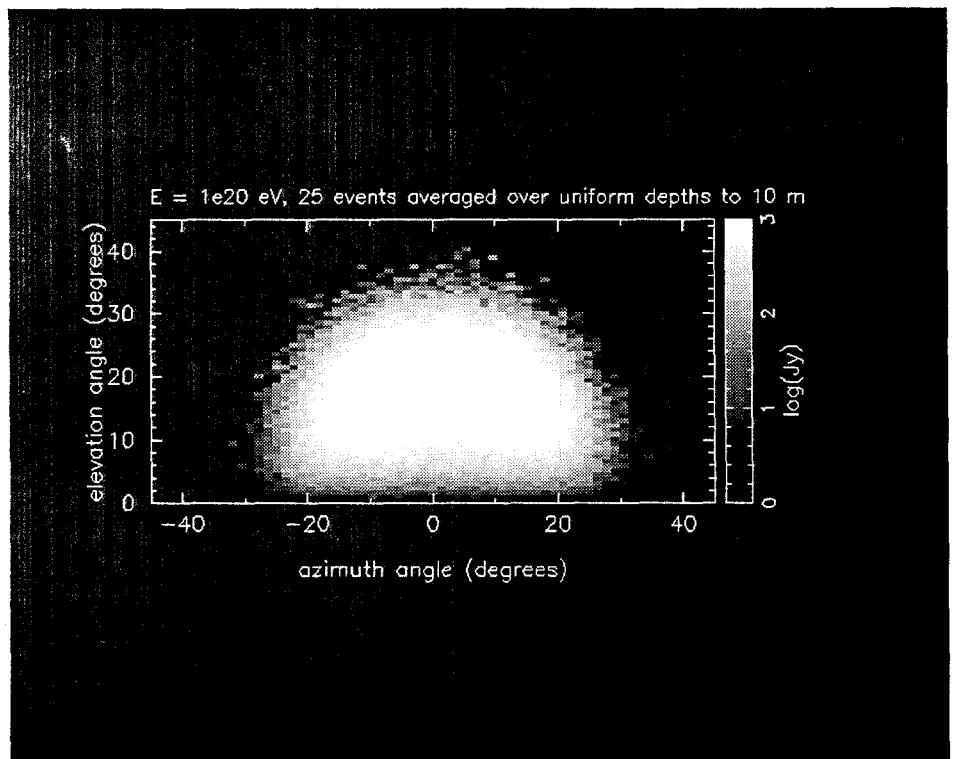
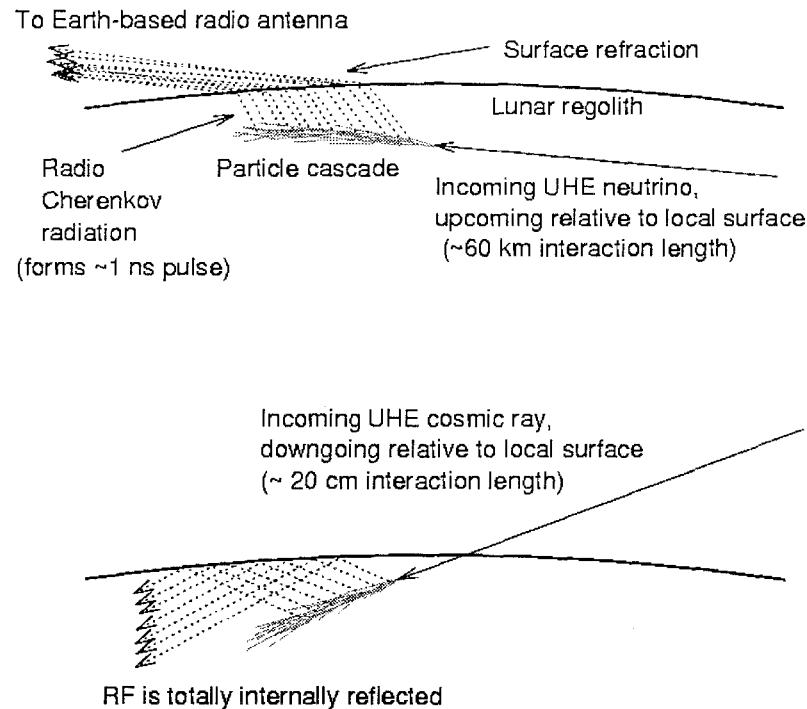
- G. Askaryan, early 60's:
 - HE particle cascades produce ~20-30% more electrons than positrons
 - compton scattering, e+ annihilation, delta rays, etc.
 - => showers in dielectric produce coherent microwave Cherenkov radiation
 - One should look for low-loss microwave dielectrics abundant in nature
 - Ice, many rocks
 - Lunar regolith--a surface array on the moon!
- Immediate application was found in air showers (J. Jelley)
 - But the dominant process in EAS is not coherent Cherenkov
 - probably boosted dipole radiation from geomagnetic charge separation
 - No follow-up on Askaryan's suggestion of solid dielectrics till 80's
- 1988: I. Zheleznykh & R. Dagkesamansky:
 - propose that $1e20$ eV neutrino events may be detectable from earth
 - First experiment (Hankins et al 96) done in 1994 w/ Parkes 64m
 - null result in 10 hours single-dish observation

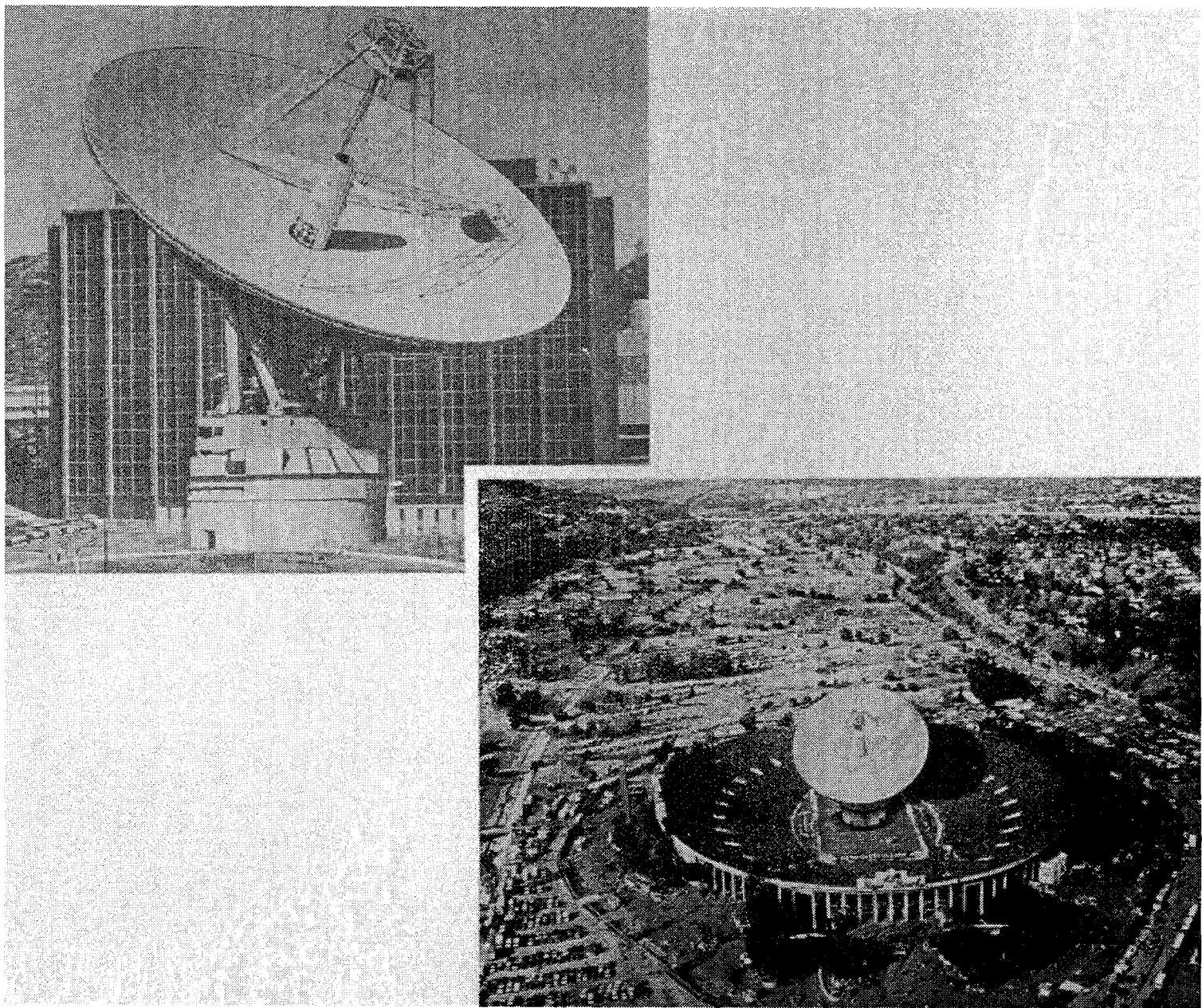
Goldstone experiment



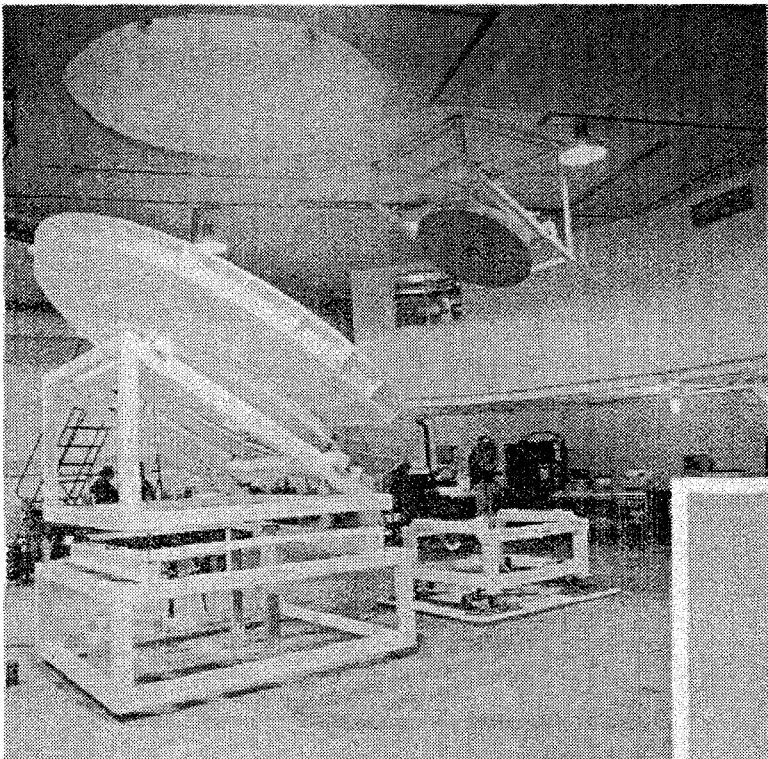
- Utilize Deep Space telecom 70m antenna DSS14 for lunar RF pulse search--fill gaps in SC sched.
- First observations late 1998:
 - approach based on Hankins et al. 1996 results from Parkes
 - utilize active RFI veto
- 1999: add 2nd 34 m fiber-linked antenna DSS13
 - initially used passive recording with local trigger at DSS14
- 2000: DSS14 down for first half, but ~20 hours livetime acquired since July
 - focussed on limb observations, lower threshold, better trigger system

Lunar Regolith Interactions & Cherenkov radiation

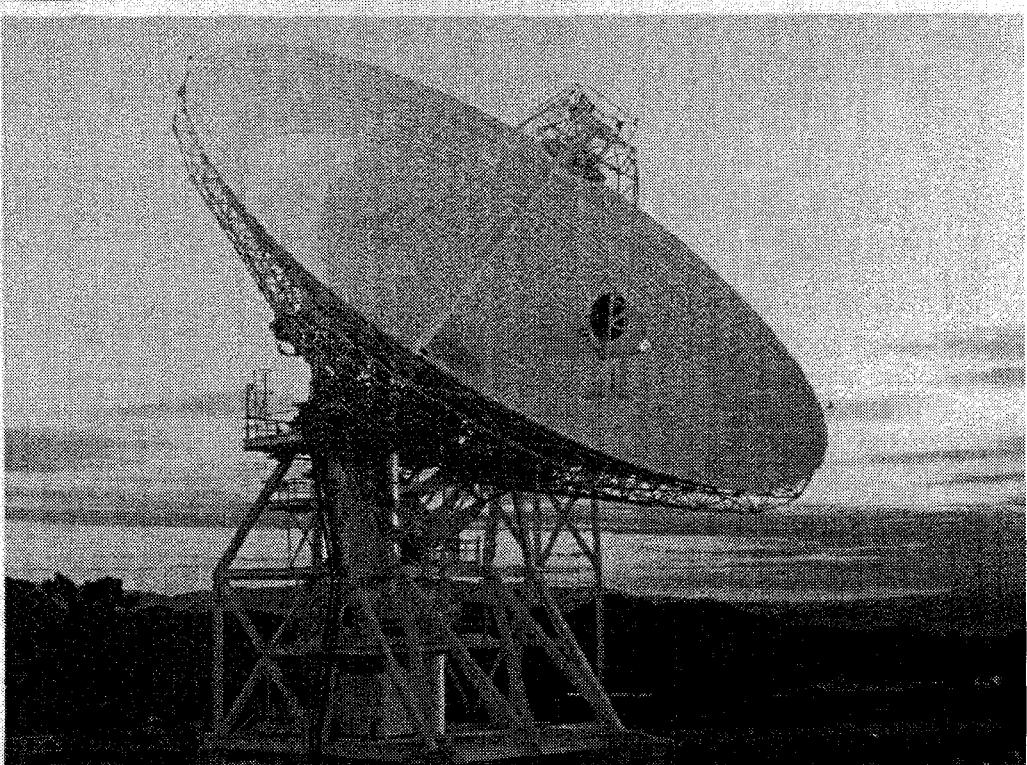




DSS13: 34 m Beam waveguide antenna

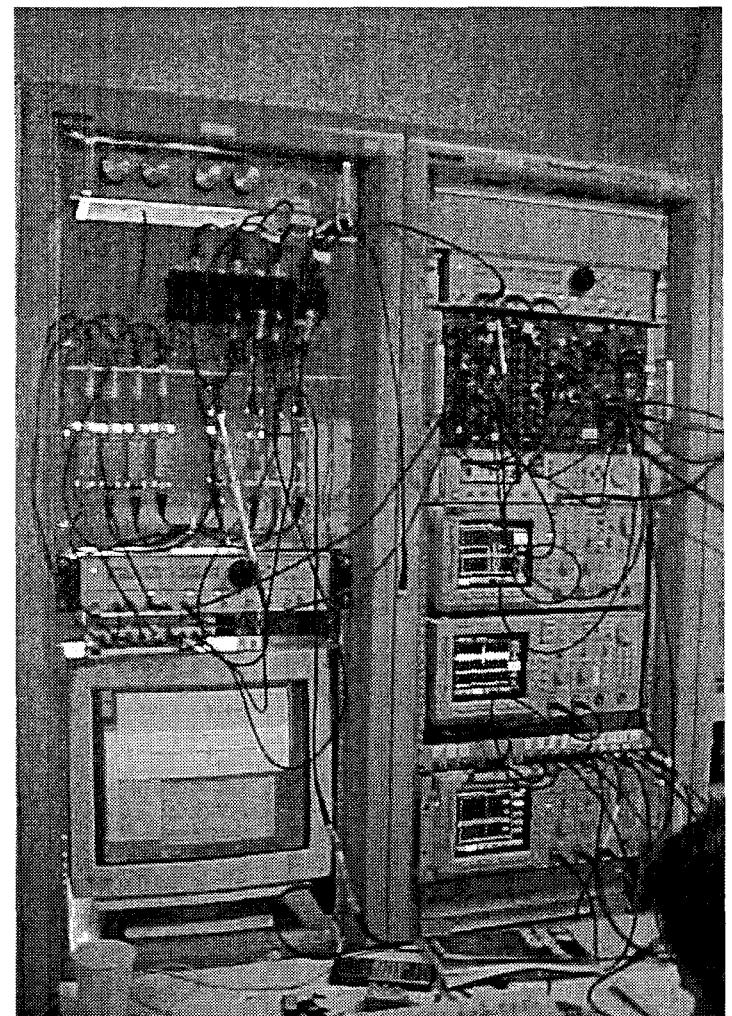
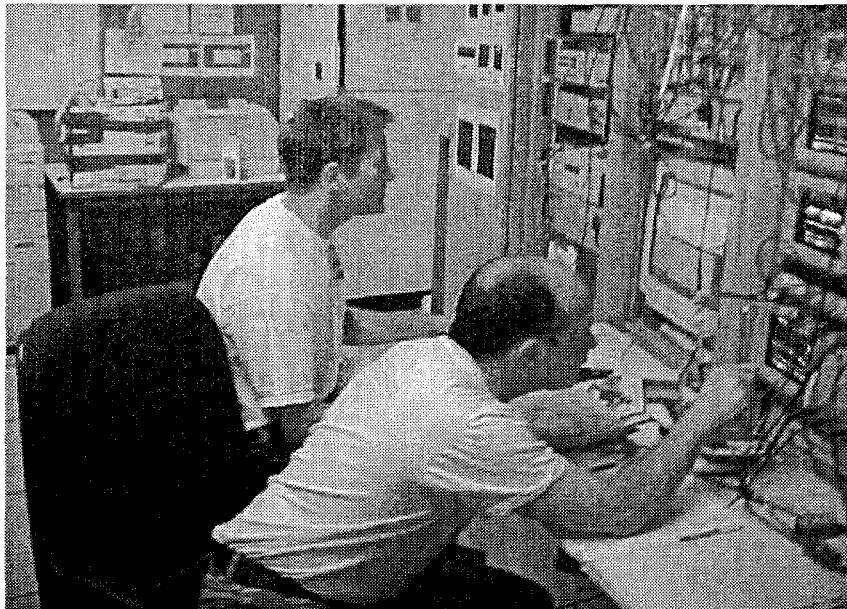


- DSS13: research antenna
- Uses “beam waveguide” optics
 - low-freq cutoff at ~1.8 GHz
- High efficiency, excellent surface
- At present: 140 MHz BW (S-band)
 - single pol, dual pol planned for ‘01

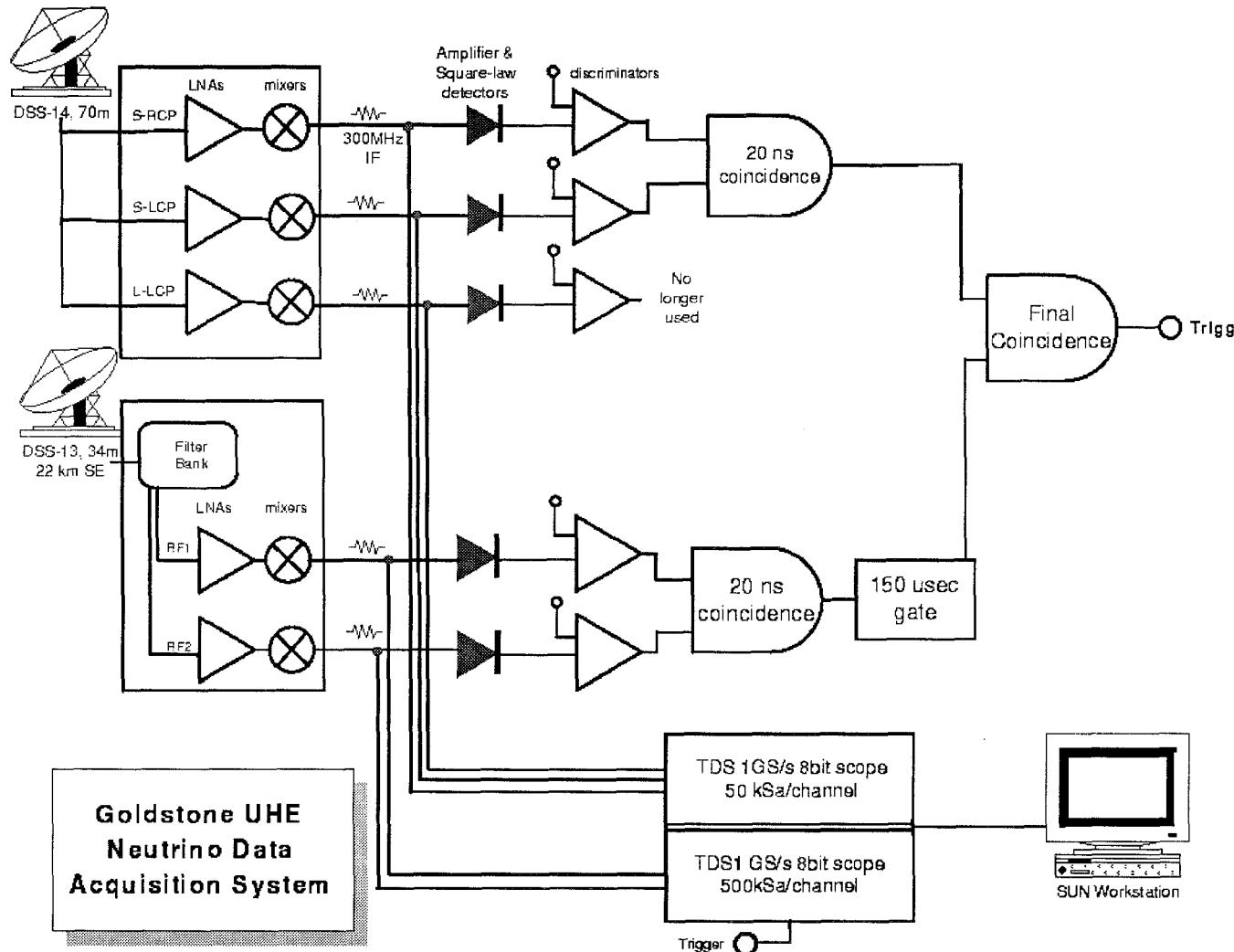


New RARG location

- Two relay racks of our own
- JPL tech support
- DSN committed to 120+ hours of exposure
- New trigger
- ~8 visits, ~ 20-30 hours livetime

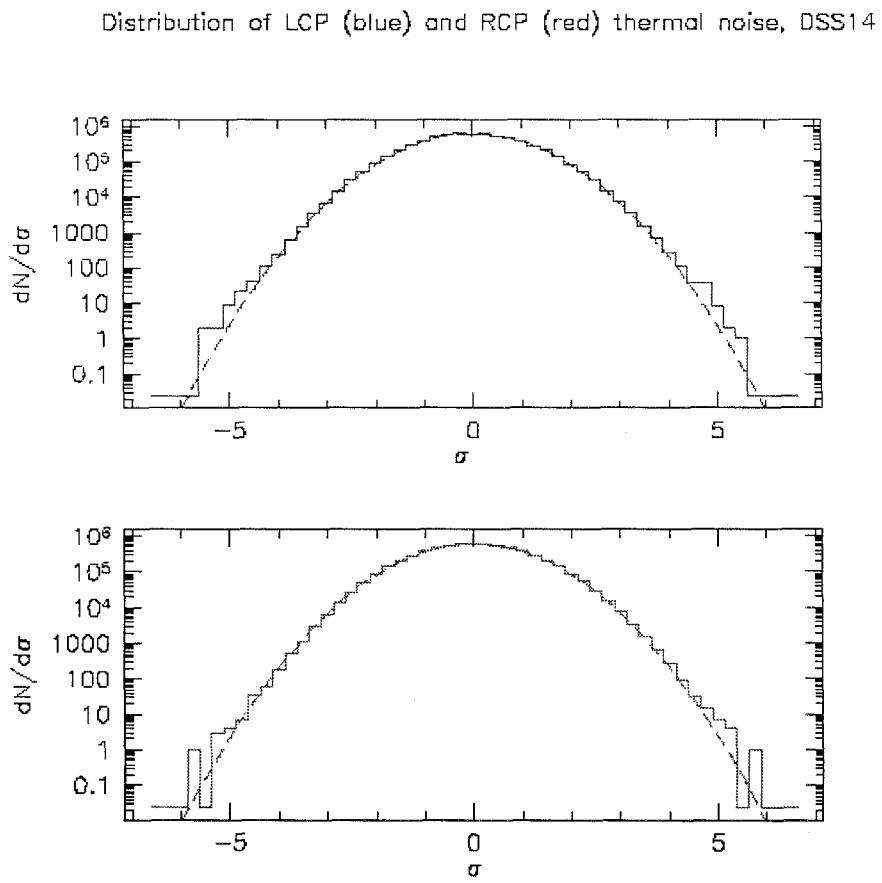


New Trigger



- RFI veto:
 - no longer in trigger
 - record off-axis L-band signal for post-analysis
- Pulses at both antennas now required for trigger
 - powerful interference rejection
 - disc. thresholds set according to relative aperture
- Thermal noise coincidence rates ~0.2 per minute
 - but only ~1/day close to proper moon delay

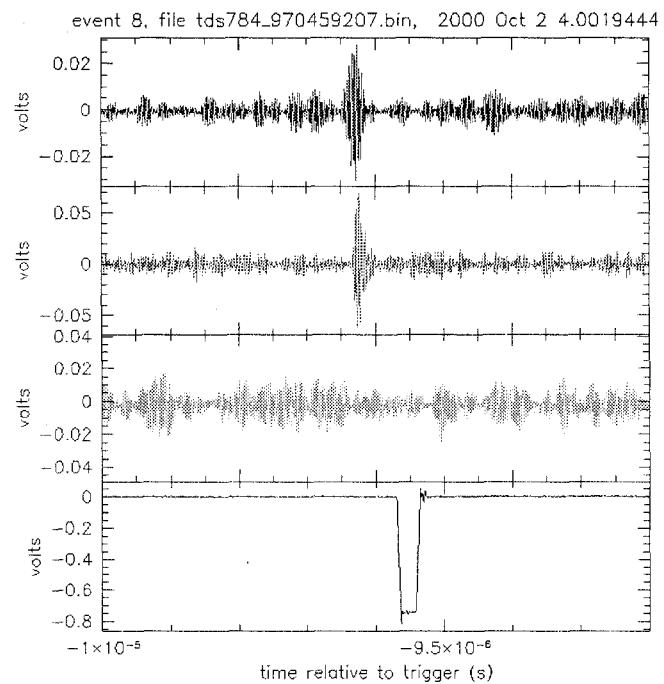
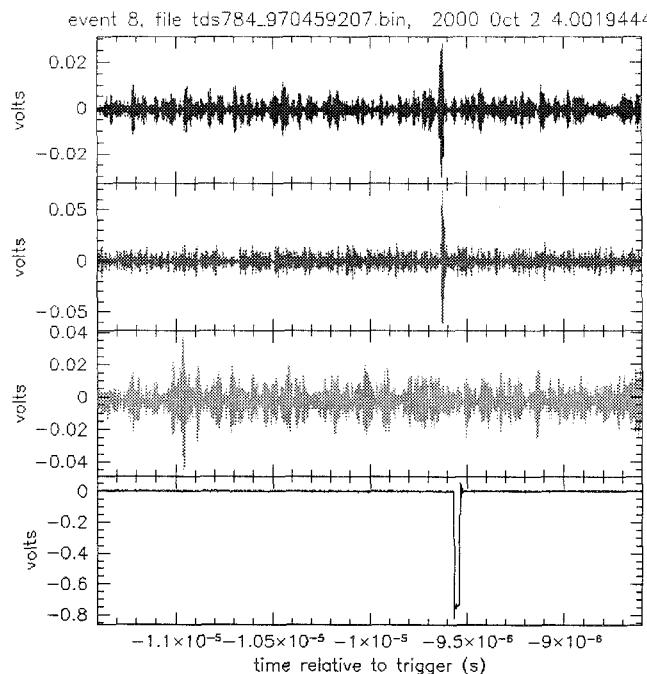
Thermal Noise Statistics



- Voltages proportional to pulse field strength: pure gaussian:
 - $\Rightarrow dN/dV \sim \exp(-V^2)$
- Square-law detection used for discrimination
 - $\Rightarrow \text{Power} \sim V^2/Z$
 - $\Rightarrow dN/dP \sim dN/dV$
 - $\sim \exp(-I)$
- Statistics of detected power are exponential
- $\Rightarrow 5$ sigma equivalent significance requires $\text{SNR} \sim 15$

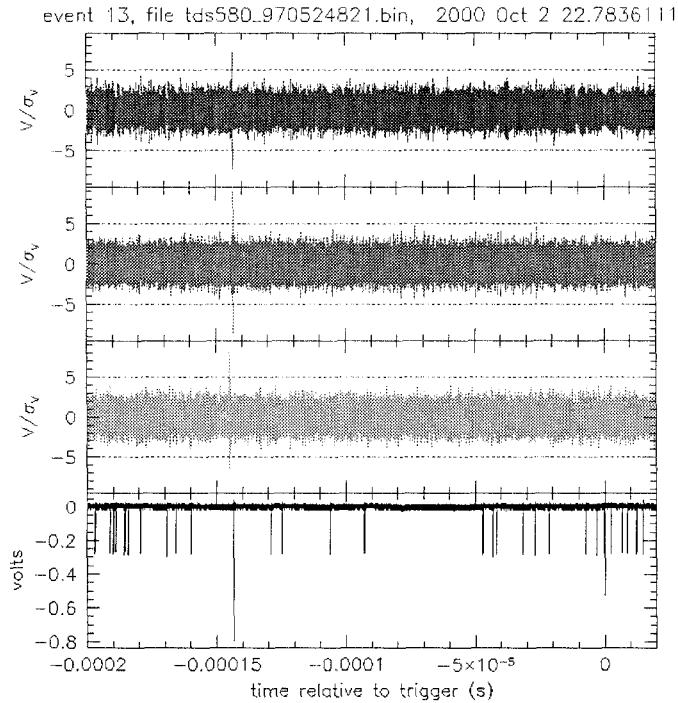
Timing & pulse shape calibration

- S-band Monocycle pulser:
 - provides band-limited lin.pol. Pulses
 - checks amp. Linearity, net cable delays, band-limited pulse shape



- Zoomed version: LCP pulse is broader (40 MHz BW), RCP narrower (~100MHz BW); also slight timing offset

Typical RF interference trigger

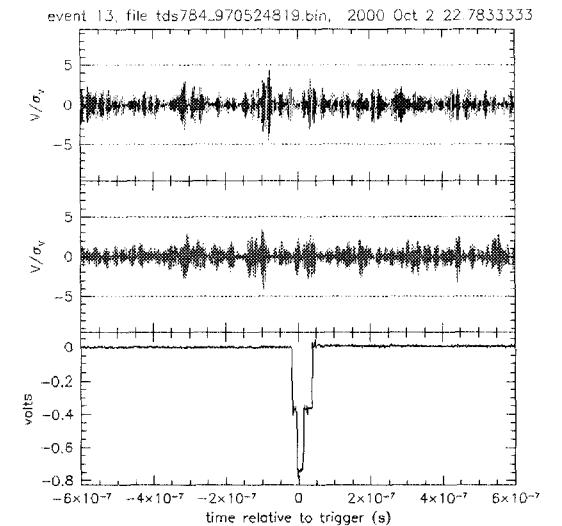
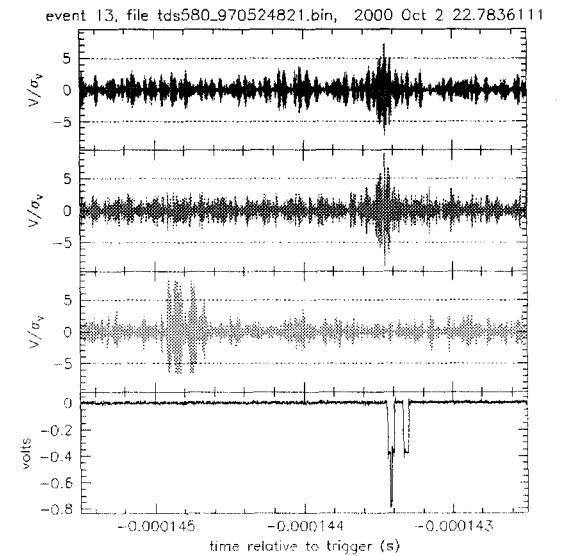


One of the 2 antennas
may have high RFI
singles rates

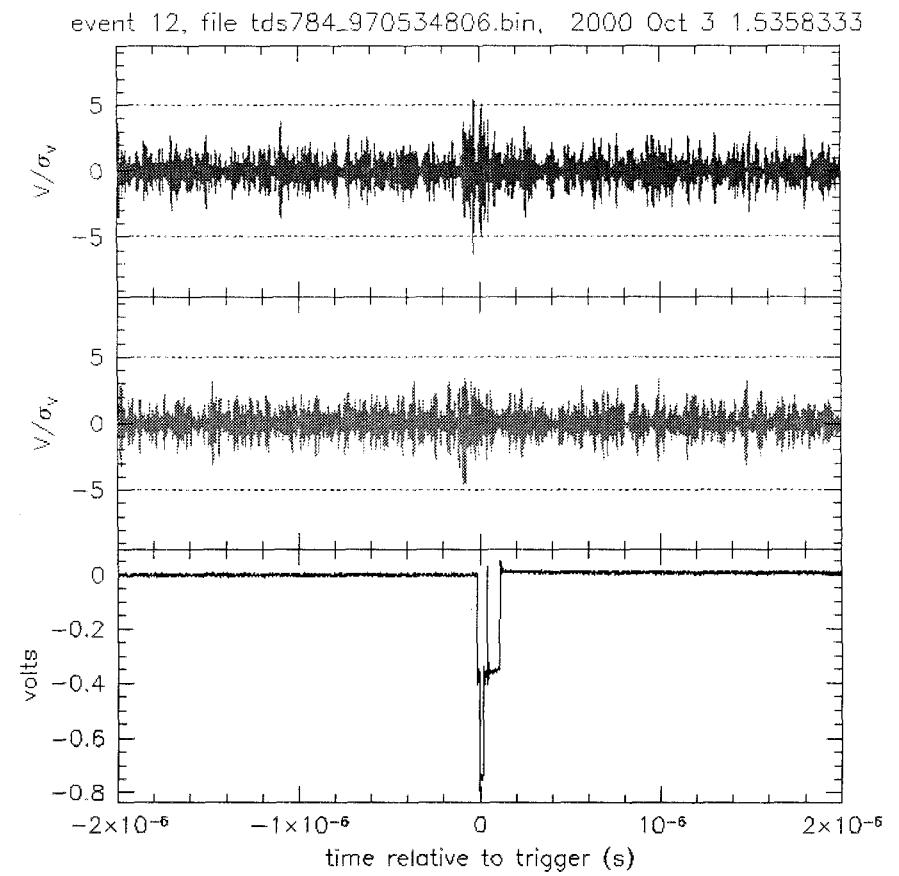
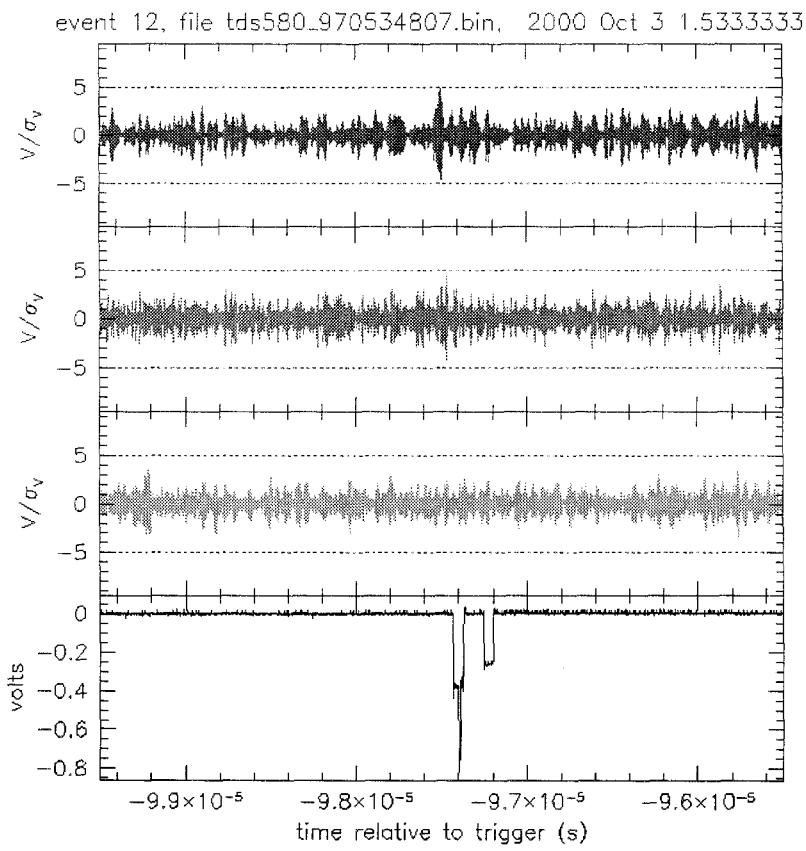
Will produce excess
coincidence rate with
2nd antenna thermal
noise

Events are clearly
distinguishable: L-
band channel pulse is
present

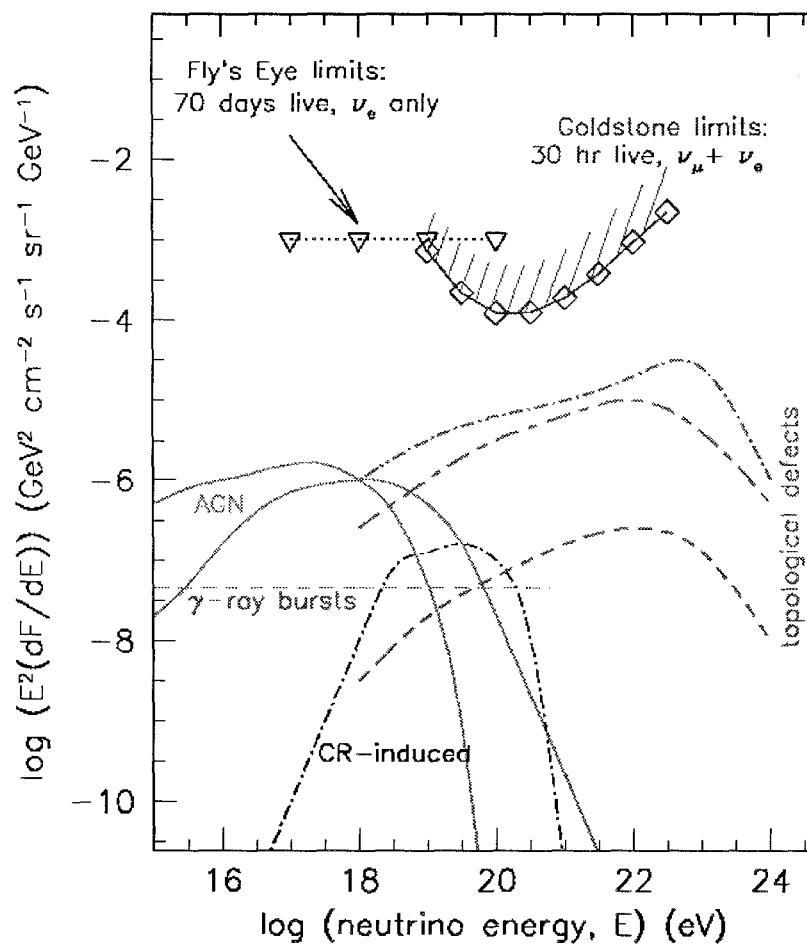
Overall increase in
trigger rates ~10%



Typical Thermal Noise trigger



Goldstone diffuse neutrino flux limits



~30 hrs livetime (includes previous data)

- No events above net 5 sigma

New Monte Carlo estimates:

- Xsection ‘down’ by 30-40%
 - moving target effect!
- Full refraction raytrace, including surface roughness, regolith absorption
- Y-distribution, LPM included

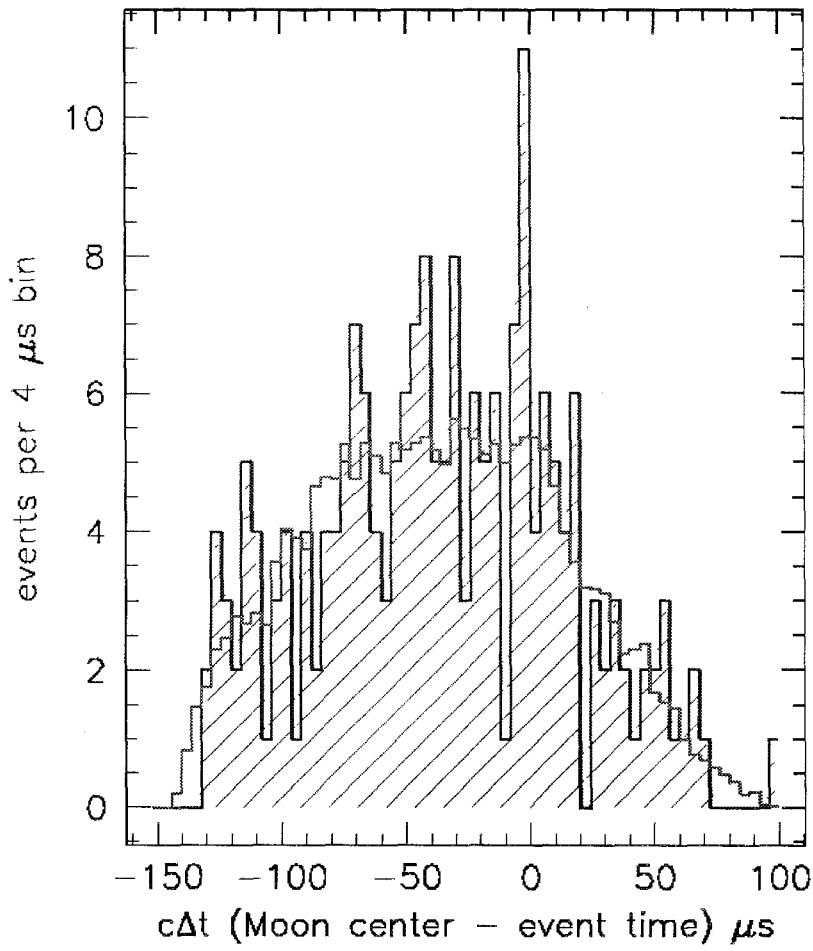
Limb observations:

- lower threshold, but much less effective volume
- Weaker limit but with more confidence

Fly’s Eye limit: needs update!

- Corrected here (PG) by using published CR aperture, new neutrino xsections

Statistics of non-RFI triggers near threshold



Cuts applied:

- tighter timing
- pulse width close to band-limited
- not obvious RFI

BKG weight determined by randomizing event UT within run period

Some concentration of events near correct delay:

- not significant yet
- ~2 microsec offset hard to explain

Future plans

- Still ~100 hours more dual antenna time to be scheduled in next 6-8 months
- New strategy: use partial defocussing at DSS14 (J. Ralston suggestion) to improve effective volume
 - expect factor of 5-10 improvement with only modest increase in energy threshold
 - DSS14 beam will better match DSS13 beam & response
- Improve bandwidth, get dual polarization at DSS13
 - Could lead to roughly equal sensitivity for two antennas